Trans Mountain Pipeline ULC
Trans Mountain Expansion Project
NEB Hearing Order OH-001-2014
Responses to Information Request from
Dorothy Doherty

At this point I wish to express my dissatisfaction with the replies I received for Information Request No 1. In many cases I was required to find the answer to my questions in other people's responses, or other documentation that was difficult to find, often with no reference numbers. I would appreciate answers to this IR in one document.

2.1 Tunnel through Burnaby Mountain

Reference:

A4F5D5 Part 1 Westridge Delivery Line Routing Update.

A4F5D5, page 75. 7.0 Conclusions, Table 7.1 Comparison of Options. Option 2 (Tunnel), under Other, states:

"A tunnel could be built to accommodate 3 pipelines, to support the relocation of the existing NPS 24 delivery line."

TV interview with Kinder Morgan Canada president Ian Anderson, Global News, Wednesday, December 3, 2014, 7:11 pm. 14:39, Interviewed by Jill Krop. Part 2.

Discussion on relocating existing pipeline routes through Burnaby residential areas at 5:30-5:59. Dismantle existing pipeline 9:21.

Preamble:

The most recent documents focus on building a tunnel through Burnaby Mountain. Most questions in this section deal with the size and construction of the tunnel. It has been stated that the tunnel will run about 150 to160 metres below the surface, and that there will be two, possibly three, pipelines going through the tunnel. I wish to point out that some of these questions were compiled before Trans Mountain documentation was submitted to the NEB, and may have been answered in recent documentation that I have not yet read. I am trying to determine which pipelines will be built in the initial stage of construction, and if a third pipeline will be added during the initial stage, or later.

Request:

a) What is the rationale for two pipelines of 30 inches each instead of a single pipeline of 36 inches?

b) What is the rationale for the third pipeline?

c) 2.2.3, Operations and Maintenance, states,

> "The two NPS 30 delivery pipelines as well as the existing NPS 24 pipeline will operate intermittently…".

d) Is the NPS 24 pipeline the line that currently runs through Westridge? If yes, please clarify if there are actually two or three pipelines running through the tunnel during the initial phase of construction, or if the NPS 24 line will be added later?

e) In the main body of the document, it seems like three pipelines are a certainty. In Table 7.1, it seems like it is only a proposal, and that the decision will be made at another time and in another Hearing. Which is correct? Isn't it important to have approval of all three pipelines right from the start, particularly in terms of engineering? The relevant text is below:

> "As an added benefit, if the Project is approved, Trans Mountain would consider relocating the existing NPS 24 Westridge Delivery Pipeline to the tunnel through Burnaby Mountain. Trans Mountain's proposal to relocate the existing NPS 24 pipeline is not part of the Application before the NEB and would be part of a separate Regulatory application; however, the option to relocate the existing NPS 24 pipeline within the tunnel factored into Trans Mountain's decision to pursue the tunnel option."

f) Although relocating the NPS 24 pipeline is not included in the documentation for this hearing, it is clear that plans are being made to relocate the NPS 24 line through the Burnaby Mountain tunnel. How does this plan change the dimensions of the proposed tunnel through Burnaby Mountain?

g) 2.2.1 states "the two drill paths would be separated by approximately 10 to 20 metres." Please advise if the two drill paths mean two tunnels, one for each pipeline? At what point does the single tunnel split into two drill paths? What is the proposed path of the third pipeline?

h) At about 7:00 minutes into the TV interview cited above, Kinder Morgan Canada president Ian Anderson states that if the pipeline incurs a leak or other problem, no repairs will be done. He indicates a sleeve will be inserted to resolve the issue. Please explain how this is done, and why there is no room in the tunnel to make the type of repairs typically done with existing pipelines. Please describe this sleeve, and how workmen will access the pipeline should repairs be required? Will the insertion of a sleeve reduce or impede the flow of dilbit in any way?

i) Please provide a diagram outlining the position of all proposed pipelines within the tunnel.

j) How soon after the expanded pipeline is complete will the Westridge leg of the pipeline be decommissioned?

k) At 9:30 minutes, it is stated in the TV interview that the life of the pipeline is indefinite. Please give a rough estimate in years what the life of the pipeline might be.

l) Are the materials in the proposed pipeline the same or better than the existing pipeline, and in what way?

m) Please describe what safety measures are installed in the tunnel to alert the company of spills and ruptures and other unforeseen problems.

n) Please describe a possible scenario inside the tunnel where a rupture has taken place, citing how this rupture will be stopped and repaired.

o) Given that the pipes will be surrounded by an impermeable concrete (2.2.2), would there be any advantage to a double walled (one pipe inside another) pipeline? What are your reasons for this choice of construction?

p) What is the industry experience with impermeable concrete in terms of tunnel construction as it relates to seismic occurrences?

q) How does this impermeable concrete compare with typical construction grade concrete, in terms of how it behaves in the ground (in this case, shale/conglomerate)? Construction grade concrete requires expansion joints to prevent cracking. Will cracking be an issue with the impermeable concrete, and if so, what measures are taken to deal with the possibility of cracking? Is there any chance that petroleum products like dilbit or distillate can seep through expansion joints (or a similar mechanism) in the event of a rupture? How will you know there is a break in the concrete, or a rupture in the pipe? In the event of a breach, rupture, or leak, how will clean-up be carried out?

r) Please give existing examples of the same type of construction elsewhere for use with oil pipelines.

s) Are there more than two entries with which to access this leg of the pipeline? Where are they located?

t) What is the estimated duration for the construction phase of the tunnel through Burnaby Mountain?

u) Is construction planned during daytime hours only, or around the clock? What is the likelihood of sound from building the tunnel disturbing residents and wildlife?

Response:

a) Different oil products are transported from Edmonton to the Burnaby Terminal (tank farm) in “batches” and segregated in different tanks. Multiple delivery lines are then required from the tanks to the Westridge Terminal, dependent on the product to be shipped by tanker. The need for 3 delivery pipelines is described in the Facilities Application, Section 3.4.4.1.4 (Filing ID A3S0Z0 PDF Page 5 of 7) so up to three tankers can be loaded at the same time with different products.

b) The third pipeline, which may be considered to be installed in the tunnel would require a separate regulatory approval process, would be a relocation of the existing pipeline which runs through the streets between our Burnaby and Westridge Terminals.

Feedback from the City of Burnaby and Westridge area residents indicated an interest in exploring deactivating the existing NPS 24 pipeline that currently runs through the Westridge neighbourhood and rerouting it through the proposed tunnel through Burnaby Mountain, subject to tests and studies determining feasibility and NEB approval. Please refer to the response to City of Burnaby IR No. 2.134i for additional information:

> *The September 25, 2014 letter to Westridge neighbours informed residents of Trans Mountain's understanding that many neighbours in the area would prefer to see the new proposed pipeline routed through Burnaby Mountain to avoid the residential neighbourhood along with city streets. The ability to route through Burnaby Mountain would avoid several private homeowners and minimize community disruptions.*
>
> *The letter also acknowledged the interest by residents in exploring deactivating the existing pipeline through the Westridge neighbourhood and rerouting it through Burnaby Mountain, subject to tests and studies determining feasible and NEB approval.*
>
> *The City of Burnaby also expressed interest in the potential community benefits of moving the existing Westridge pipeline into the new alignment as noted in Consultation Update No. 2, Section 1.5.8 (Filing ID A3Z8J2) and City of Burnaby Supplemental Consultation Record June 30, 2014 (Filing ID A3Y7F5). Although deactivation of its existing pipeline and relocation within the proposed pipeline corridor would require further study and discussion between Trans Mountain and stakeholders, Trans Mountain committed to investigate this option.*
>
> *As indicated in the Technical Update 4 – Westridge Delivery Line Routing Update (Filing ID A4F5D5) if this concept is found feasible, Trans Mountain intends to move its existing pipeline, which runs through the Westridge Neighborhood, to alongside the new line proposed in the expansion plans. This process would require a separate application with the NEB, which Trans Mountain has not yet filed. If the Trans Mountain Expansion Project is approved by the NEB, Trans Mountain will construct a tunnel that could hold both the existing line and the new proposed line.*

The response to NEB IR No. 3.104b (Filing ID A4H1V2) provides information on regulatory process and timing.

c) Trans Mountain notes the intervenor has not provided a question in the sub-section, and, therefore, no response can be provided.

d) Please refer to the response to b) on possible timing.

e) Please refer to the response to b) above.

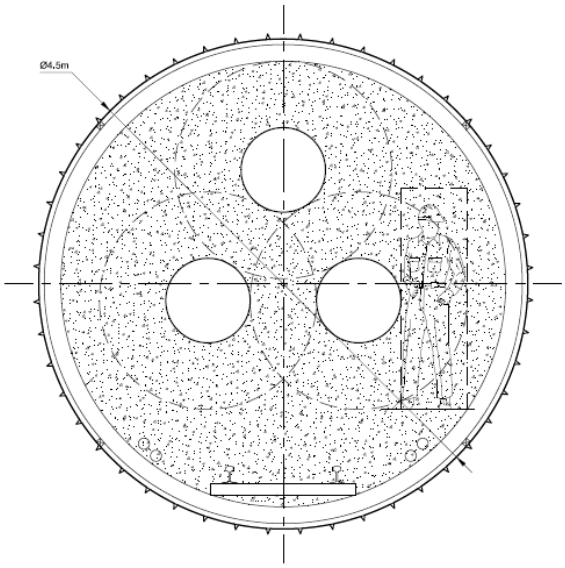
f) Please refer to the response to b) on process to be followed if the NPS 24 is proposed to be relocated into the tunnel. Please refer to the response to NEB IR No. 3.104a (Filing ID A4H1V2) on dimensions of tunnel for two or three pipelines.

g) In addition to tunnelling, Trans Mountain also studied other means of directionally drilling individual delivery lines through the mountain. Trans Mountain confirms that it is the tunnel option that has been selected as the preferred solution, an outcome by which the existing NPS 24 pipeline may potentially be relocated.

h) The pipeline tunnel is still in the preliminary design stages. One of the design considerations will be whether or not the tunnel will accommodate access for maintenance and repair of the pipelines. If the design accommodates access, conventional pipeline repair methods will be utilized. If access is not provided in the design of the tunnel, conventional pipeline repair methods will not be possible and an alternative repair method will need to be developed.

i) Final configuration of tunnel diameter and pipe installation will depend on the selected Contractor's means and methods which may be influenced by chosen tunnel construction and tunnel backfill methods.

As a representation only at a feasibility level stage, the following backfilled pipe arrangement may be appropriate. Note that the third pipeline is shown indicatively only for approximate sizing purposes.



SECTION
PIPES WELDED INSIDE THE TUNNEL
FINAL CONDITION FOR 3X NPS 30

j) Please refer to the response to b) above.

k) Oil pipelines such as Trans Mountain pipeline (TMPL) are not designed to have a limited life, because the fundamental material properties of steel do not change appreciably with time, and therefore pipelines have an indefinite life as long as preventative maintenance and integrity management practices are in place. Kinder Morgan Canada has a strong

focus on regular preventive maintenance and a well developed integrity management program including regular inspections with the best available In Line Inspection (ILI) technology. With application of the latest technology, and sound operating practices, the TMPL has an indefinite lifespan.

l) The materials in the new pipeline will have superior quality than the materials in the existing pipeline. Improvements have been made in pipe steel metallurgy, pipe manufacturing, and inspection and quality control processes. Improvements have also been made in the materials for coating pipelines and for the application and testing of coatings to protect the pipe from time dependent degradation mechanisms like external corrosion. These material advancements coupled with improved engineering design standards and practices and construction improvements make the risk of a failure on a new pipeline extremely low. Similarly, technological advancements have been incorporated into today's integrity management programs, including risk management, and these programs are designed and regulated to reduce the risk of a spill on existing pipelines, such as TMPL, to a similarly low probability.

The Application, Volume 4C, Section 8.0 (Filing ID A3S1L1) provides information on System Integrity Management including Risk Assessment.

m) Information on leak detection is included in Technical Update No. 4, Part 1, Westridge Delivery Pipelines Routing Update, Section 2.2.3, Operations and Maintenance (Filing ID A4F5D5, PDF page 15). Kinder Morgan Canada (KMC) will extend the existing computational pipeline monitoring (CPM) system to include the pipelines routed through the tunnel. New instrumentation for pressure and flow measurement for each of the pipelines will be included in the designs of Burnaby Terminal and Westridge Marine Terminal (WMT) and will provide process information to the CPM system. KMC is also planning on implementing a parallel CPM system, which uses different types of calculations to recognize leaks, to complement the existing CPM system.

In Section 2.2.2, Option 2 – Tunnelling (PDF page 14), Trans Mountain identifies the intent to backfill the tunnel with impermeable concrete to ensure the stability of the pipelines. This will also have the benefit of blocking the flow of oil in the extremely low-likelihood event of a leak.

Leak detection strategy will also include the use of smart in-line inspection (ILI) tools that will travel inside the pipelines with the flow of oil between Burnaby Terminal and WMT and which can detect small defects that have the potential to leak. KMC may also run ILI tools that have acoustical microphones, which, combined with advanced software, have the ability to detect leaks.

KMC is currently participating in joint industry projects, using large scale testing, to investigate the viability of commercially available external leak detection systems. One of the planned projects is the testing of four external leak detection technologies: vapour-sensing tubes, fibre-optic distributed temperature sensing (DTS) systems, hydrocarbon-sensing cables, and distributed acoustic sensing (DAS) systems. When the tunnel moves into detailed engineering and design, these new technologies, if proven to be

commercially viable, will be considered as possible enhancements to the CPM leak detection systems.

n) Please refer to the responses to NEB IR No. 3.110a and 3.110b, and NEB IR No. 3.103g (Filing ID A4H1V2), which are included below:

"Please refer to the response to NEB IR No. 3.103g (copied below) for specific design considerations and safety measures that will be employed with the Burnaby Mountain tunnel design to minimize the potential for a leak from a segment of the Burnaby to Westridge delivery lines. As indicated, conservative design considerations will be employed which will limit the potential of a spill or leak to a very low likelihood.

In the event a leak was detected, and in recognition that the location of the leak could be at an inaccessible location of a segment of the pipeline encased in concrete, the following actions would be considered in the response:

- Immediately upon the detection of the leak, drain the Westridge delivery line segment so that oil is removed;
- Use cleaning pigs and nitrogen to remove any residual oil remaining which is adhering to the pipe wall;
- Assess repair options or replacement options, which may include installation of a smaller pipe, an internal insert or slip lining, or complete replacement of the pipeline through a new tunnel or conventional overland routing; and
- Complete a risk assessment to determine if any leaked oil has the potential to impact area receptors.

As stated in (Filing ID A4F5D5 Pg. 76 of 96) Technical Update No. 4, Westridge Delivery Pipelines Routing Update, Section 6.2 Emergency Preparedness and Response an updated Emergency Management Plan (EMP) is currently under development to address the needs of the proposed expansion. The updated EMP will use the existing KMC EMP as its foundation and will take into account issues such as the specific alignment and construction of the Westridge Delivery Pipelines. The updated EMP will be developed in accordance with the National Energy Board Draft Conditions specific to the Emergency Management Program and Emergency Response Plans.

In the event of a leak near the entry and exit portals predetermined control points will be situated in close proximity to the portals. This will assist in increasing the efficiency of response activities in that monitoring and containment can be focused at these two locations."

NEB IR No. 3.103g

Engineering and safety

3.103 Westridge delivery pipelines – options and design

Reference:

A4F5D5, Project and Technical Update No. 4, Westridge Delivery Pipelines Routing Update:

i) PDF page 8 of 96
ii) PDF page 14 of 96
iii) PDF page 15 of 96

Preamble:

Reference i) states that, based on the geotechnical and engineering feasibility information collected, Trans Mountain has decided not to pursue the HDD option (Option 1). Trans Mountain's preferred installation method for the Westridge delivery pipelines is now via a tunnel through Burnaby Mountain from Burnaby Terminal to the Westridge Marine Terminal (Option 2). Trans Mountain has determined that both the proposed tunnel option and the proposed revised alternative corridor using Burnaby streets (Option 3) are feasible and requests that the Board examine both Options 2 and 3.

Reference ii) states that the tunnel would be excavated using a tunnel boring machine with a minimum diameter of 4 m. Following pipeline installation, the tunnel would be backfilled with impermeable concrete to reduce the potential for pipe movement, to prevent the tunnel from being used as a flow path for groundwater, and to block the flow of oil products in the low-likelihood event of a leak. Excess spoil material from tunnel excavation would be disposed of at an approved location, such as a landfill.

Reference iii) states that 31 per cent (4 of 13) rock core samples tested were identified as having the potential for acid-generating conditions and that metal leaching will need to be considered for safe disposal of waste rock.

Reference iii) also states that the option of a tunnel between Burnaby Terminal and the Kask industrial property and the use of the Direct Pipe® trenchless construction technique from the Kask property to the Westridge Marine Terminal (Option 2B) was also considered and discounted, although this option was referred to subsequently in the feasibility report and accompanying reports.

Request:

g) Please discuss a method of providing secondary containment for either the pipes or the interior of the tunnel (e.g., a liner), assuming a leak of product will occur.

Response:

g) Trans Mountain's Burnaby Mountain tunnel design will incorporate design features and operating procedures that recognize the unique nature of the installation and the lack of accessibility for future maintenance and repair of the sections of the Westridge delivery lines that are encased in concrete within the tunnel. The tunnel design will be included within the risk based design of the pipeline segments, and risk mitigation will include an appropriate pipeline wall thickness that reflects the nature of the installation, a high integrity pipeline coating, and stringent quality assurance measures reflective of long term integrity of the pipeline segments.

Operating procedures for the tunnel will include inspection, monitoring, and testing systems that will provide early indication of anomalies and allow for preventative measures to stop a potential leak from the pipeline.

The impermeable concrete/grout backfill will provide a secondary containment system through the length of the tunnel, though as discussed in Trans Mountain response to NEB IR No. 3.110b (copied below), the avoidance of cracking in the concrete/grout backfill cannot be guaranteed. However as was indicated in the Risk Update Report for the Westridge Delivery Lines (Filing ID A4F5F5), while concrete backfill represents an unconventional installation configuration for transmission pipelines,(and indeed represents an extraordinary precautionary design detail), there is ample experience with down-hole (production) applications that indicate the effectiveness of impermeable cement as a means of creating a seal in a casing in which the pressure membrane has been breached.

The Quantitative Geohazard Frequency Assessment – Burnaby Mountain (Filing ID A4F5F6) documents a low likelihood large-scale ground movement associated with a landslide. Under such a scenario, and as is indicated by the results of the risk model, this scenario is considered to be low likelihood and there is no design measure (e.g. a liner) that would prevent or contain a release of oil from such an event.

Failure frequency and outflow analysis presented in the Risk Update Report for the Westridge Delivery Lines (Filing ID A4F5F5) is based on the above considerations, and takes into account the fact that the planned inline tool reassessment interval is frequent enough to pre-emptively detect time-dependent volumetric flaws prior to any breach of the steel pressure membrane. As a further level of precaution, Trans Mountain will commit to deploying acoustic leak detection tools on a regular basis to ensure that no pinhole leaks are present. This will address the potential for any loss of containment that would otherwise go unnoticed that might arise from any threat mechanism, including time-dependent threats and manufacturing defects. With respect to other threat mechanisms, while the effectiveness of acoustic leak detection is independent of threat, it is difficult to envision an operations-related failure that would result in an

un-noticed leak inside a concrete filled tunnel, and third party damage may be ruled out as a realistic threat under such circumstances.

Given the above considerations and commitments, adoption of further containment, such as a liner for the tunnel or pipeline segments, has not been provided as part of the tunnel or pipeline design through Burnaby Mountain, and is not considered necessary given the low potential risk and precautionary measures that are being adopted for the design of the installation. Trans Mountain's pipeline design team has assessed that the backfilled tunnel is similar in characteristic and poses similar risks to any other deep trenchless crossings for example HDD or Direct Pipe® in which no liners are deployed.

NEB IR No. 3.110b

Engineering and safety

3.110 Westridge delivery pipelines – risk assessment

Reference:

A4F5D5, Project and Technical Update No. 4, Westridge Delivery Pipelines Routing Update:

i) PDF pages 76 and 77 of 96
ii) PDF page 46 of 96
iii) A4F5F0, Project and Technical Update No. 4, TMEP Westridge Tunnel Investigation – 2014 Site Investigation Data Report, Appendix I – Waterline Technical Memorandum, PDF pages 21 and 22 of 28

Preamble:

Reference i) states that the backfilling of the annulus between the delivery lines and the tunnel wall will be done using impermeable lightweight cellular concrete. The backfill material will form a barrier to flow. The concrete-filled tunnel will minimize the potential for leaked oil to escape from the leak source. It also indicates that, although this represents an unconventional installation configuration for transmission pipelines, there is experience with this technology in downhole applications.

Reference ii) states that pipe welding inside the tunnel has been accommodated by the design.

Reference iii) notes the presence of methane as dissolved gas in the groundwater. The concentration of methane is reported as being in the range of 120 to 310 ppm, emphasizing that the methane gas concentration may be greater than measured due to keeping the borehole open for sampling.

Reference iii) also states that the presence of dissolved methane within the aquifer screened by the test well is confirmed and monitoring of the methane concentration is recommended during construction and tunneling.

Request:

Please provide:

b) the quality control measures that will be in place to ensure no flaws, cavities, or cracks will occur within the concrete backfill to ensure the impermeable barrier around the pipes; and

Response:

b) The final decision on the exact tunnel backfill technique will depend on the selected Contractor's means and methods which may be influenced by chosen tunnel construction and pipe installation methods. Quality control measures will be established once the exact method of backfill technique has been developed.

The most effective quality assurance for the placement of tunnel backfill is a Technical Specification written in line with current best practice that outlines specific performance requirements of the material to be placed, for example, 28 day strength, water / cement ratio, workability, heat of hydration etc. Such Technical Specifications will be developed during the detailed engineering and design phase of the project.

Notwithstanding the above, it is not possible to guarantee that the backfill will not crack during the design life of the pipeline. The likelihood of a crack occurring coincident to a flaw in the pipeline resulting in leakage is also a consideration in risk analysis, and the concrete would in any event still mitigate containment loss.

Note that this is not different from any other deep trenchless crossings for example HDD or Direct Pipe®. As such, for installations that are not readily accessible, an appropriate pipe wall thickness and coating as well as advanced in-line inspection, monitoring and testing systems are selected to ensure safe operation of the pipeline.

o) Please refer to the response to NEB IR No. 3.103g (Filing ID A4H1V2) for discussion on a similar concept.

p) Further discussion on a feasible tunnel backfilling technique and associated risks can be found in Section 6.6 of Burnaby Mountain Tunnel and Trenchless Feasibility Report which is part of the Westridge Delivery Line Routing Update (Filing ID A4F5D6).

"The backfill will be placed from within the tunnel or from the portals to completely fill the tunnel and seal off groundwater discharge. During backfilling, emphasis will be made to control pipe buoyancy due to uplift forces from the backfill weight, to prevent pipe buckling due to excessive injection pressure during backfilling, and to limit the heat generated during hydration of cement to prevent development of a gap between the backfill and the pipe. The backfill material will be designed to prevent damage of the pipe and to provide both final support and seepage cut-off. The typical tunnel backfill materials that can be used are cement grout and concrete."

Examples of where this backfill grouting has been used to fill the annulus after pipe installation in a tunnel include Metro Vancouver's Seymour Capilano Twin Tunnels, Metropolitan Water District of Southern California's Riverside Badlands, and Arrowhead tunnels, King County Washington's Brightwater Conveyance tunnel.

Trans Mountain envisages letting the tunnel construction contractor be involved in the development of the tunnel backfill technique. The final decision on the exact tunnel backfill technique will depend on the selected Contractor's means and methods which may be influenced by chosen tunnel construction and pipe installation methods.

Steel pipes and penstocks are routinely backfilled in tunnels for various applications ranging from utility, water / wastewater conveyance to hydropower. On a recent hydropower project in Northern British Columbia a concrete backfilled 60 year old operational steel penstock was exposed, sampled and tested for corrosion and deterioration of integrity. The results confirmed that there was zero to negligible corrosion or deterioration of material and the backfill concrete performed well to maintain the structural integrity of the penstock.

During the operational lifetime of the pipeline the tunnel will be backfilled with cement grout, therefore ensuring the structural stability of the excavation. From a pipeline structural integrity point of view the following may be considered:

Ground motions generally decrease with depth below the ground surface, such that the value of Peak Particle Acceleration (PPA) at depth is generally lower than that estimated for surface motions, *i.e.* the Peak Ground Acceleration (PGA). Power *et al.* (1996) suggests the following ratios be applied to obtain ground motions at depth:

Depth [metres]	Ratio of Ground Motion at Depth to Motion at Ground Surface
≤ 6	1.0
6 to 15	0.9
15 to 30	0.8
> 30	0.7

Hashash *et al.* (2001) presented a 47-page review which provided a summary of the current state of seismic analysis and design of underground structures. From a review of more than 500 case histories, the following general observations were made regarding the seismic performance of underground structures (as quoted from Hashash *et al.*, 2001):

1. Underground structures suffer appreciably less damage than surface structures.
2. Reported damage decreases with increasing overburden depth. Deep tunnels seem to be safer and less vulnerable to earthquake shaking than are shallow tunnels.
3. Underground facilities constructed in soils can be expected to suffer more damage compared to openings constructed in competent rock.

4. Lined and grouted tunnels are safer than unlined tunnels in rock. Shaking damage can be reduced by stabilizing the ground around the tunnel and by improving the contact between the lining and the surrounding ground through grouting.

Therefore, at depth the potential for any damage to the pipeline from seismic activity is reduced compared to near surface installations.

References:

Power, M.S., Rosidi, D. and Kaneshiro, J., 1996. Volume III Strawman: Screening, evaluation, and retrofit design of tunnels, Report prepared for National Center for Earthquake Engineering Research, Buffalo, New York.

Hashash, Y., Hook, J., Schmidt, B., and Yao, J. 2001. Seismic Design and Analysis of Underground Structures. Journal of Tunneling and Underground Space Technology. Volume 16 (2001). Pgs 247-293.

q) The final decision on the exact tunnel backfill technique will depend on the selected Contractor's means and methods which may be influenced by chosen tunnel construction and pipe installation methods. Quality control measures will be established once the exact method of backfill technique has been developed.

The most effective quality assurance for the placement of tunnel backfill is a Technical Specification based on current best practice that outlines specific performance requirements of the material to be placed, for example, 28 day strength, water / cement ratio, workability, heat of hydration *etc*. Such Technical Specifications will be developed during the detailed design phase of the project.

Notwithstanding the above, it is not possible to guarantee that the backfill will not crack during the design life of the pipeline. The likelihood of a crack occurring coincident to a flaw in the pipeline resulting in leakage is also a consideration in risk analysis, and the concrete would in any event still mitigate containment loss.

Note that this is not different from any other deep trenchless crossings for example HDD or Direct Pipe®. As such, for installations that are not readily accessible, an appropriate pipe wall thickness and coating as well as advanced in-line inspection, monitoring and testing systems are selected to ensure safe operation of the pipeline.

Trans Mountain has developed and implemented a systematic approach to leak detection. A computational pipeline monitoring (CPM) system is used in combination with other monitoring methods, such as surveillance patrols, regular in-line inspections using smart pigs and smart ball tools (acoustical leak detection technology), Control Centre Operator (CCO) monitoring using the supervisory control and data acquisition (SCADA) system, and scheduled line balance calculations.

In the unlikely event of a rupture, spill or any other incident affecting the integrity of the pipeline, Kinder Morgan Canada Inc. will follow their comprehensive Emergency

Management Program. Further information on the management of pipeline and facility spills can be found in Volume 7 of the application (Filing ID A3S4V5), with particular attention to Section 4.0 of this document.

r) Please see the following sample listing of tunnelled then backfilled hydrocarbon pipeline crossings are in operation / construction around the world:

Project Name	Year completed	Excavation dia. (m)	Crossing Length (km)	Country
Corrib gas field crossing	under construction	4.24	4.9	Ireland
River Exe Crossing - South West Reinforcement Gas Pipeline Project	2010	2.40	1.7	Devon, England
EMS-Dollard Crossing	2010	3.78	4.0	Germany - Netherlands
Mie Shiga Pipeline Tunnel	2014	2.32	7.5	Japan
Narrows Crossing NPS 42 Gas Pipeline	2014	4.05	4.3	Gladstone Harbour, Queensland, Australia

s) Access points to the tunnel are limited to the Burnaby and Westridge portals only throughout the construction period. There will be no permanent access to the tunnel.

t) Trans Mountain estimates that tunnel construction, including pipe installation and backfill, will take approximately 2 years.

u) Trans Mountain is committed to working with the City of Burnaby to establish days and hours of work. Detailed engineering and construction planning require further development for the Trans Mountain Expansion Project (TMEP) before details surrounding of days of work and hours of work can be answered. Trans Mountain will consider the quiet, peace, rest and enjoyment of the public in residential areas during the construction planning phase and in continued consultation with the City of Burnaby. As a federally regulated entity under the National Energy Board Act, if Trans Mountain Pipeline ULC (Trans Mountain) is granted a Certificate of Public Convenience and Necessity, it will proceed to apply for all permits and authorizations that are required by law.

Noise Management Plans that will be developed for construction and operation of the Project will incorporate the applicable components of the draft conditions as stated in the NEB's Letter – Draft Conditions and Regulatory Oversight dated April 16, 2014 (Filing ID A3V8Z8) to limit the effect of noise at sensitive receptors and include a monitoring component to verify effectiveness of controls and compliance with applicable limits. The Noise Management Plan for the Project will encompass any elements outlined in the final conditions issued by the NEB.

2.2 Water courses on Burnaby Mountain

Preamble:

Core samples from the drilling on Burnaby Mountain reveal the presence of water. How close are underground water supplies to the area where Trans Mountain plans to excavate the tunnel through which the pipeline will run?

Request:

a) How will you ensure that oil, bitumen, and/or distillates from pipeline operation and/or construction do not contaminate subterranean water systems and/or water courses downstream from the pipeline and tunnel?

b) Does the water identified by the core samples run into any of the streams on Burnaby Mountain?

c) How will this subterranean water supply be affected by Trans Mountain activities on Burnaby Mountain, either during the construction phase, or later, when the pipeline is active?

Response:

a) The groundwater beneath Burnaby Mountain flows within the bedrock which is not currently mapped, or considered an aquifer. The nearest water supply aquifer lies approximately 450 m to the southwest (Aquifer #49). It is an unconsolidated sand and gravel aquifer lying above the bedrock; it is not used for drinking water supply. Regardless of surrounding aquifer conditions, the tunnel represents an interface between the pipeline and the surrounding environment that is similar to a pipeline in a buried trench.

The measures taken to protect aquifers in the tunnel area are similar as those taken elsewhere along the proposed pipeline corridor. During construction:

- Utilize acceptable Management Practices for spill prevention outlined in the Pipeline EPP (Volume 6B of the Application [Filing ID A3S2S3]).
- During detailed engineering, Trans Mountain will complete a pipeline risk assessment and evaluate the need for additional mitigation measures (*e.g.,* thicker-walled pipe) to reduce threats and associated risk.
- Ensure that during construction no fuel, lubricating fluids, hydraulic fluids, methanol, antifreeze, herbicides, biocides, or other chemicals are spilled on the ground or into waterbodies. In the event of a spill, implement the Spill Contingency Plan (see Appendix B) (Section 7.0 of the EPP [Filing ID A3S2S3]).

During operation, Trans Mountain is committed to rapid response. In Section 6.2.2.1, Volume 7 (Filing ID A3S4V6), Trans Mountain acknowledged that "Without treatment or physical removal, oil would be a long-term source of groundwater contamination if it

contacted the water table. For this reason, spill response efforts aim to reduce potential for groundwater contamination by removing pooled oil and affected surface materials as quickly as possible, and as deeply as needed to remove contamination so that aquifers are not affected." With this focus on timely clean-up activities, impacts to aquifers can be minimized.

The Groundwater Technical Report, Volume 5C-3 in Volume 5C, Groundwater Technical Report (Filing ID A3S1U8), provides a review and inventory of potential aquifers, and their sensitivity, with associated mitigation measures.

b) The groundwater level at the tunnel entry point near the Burnaby Tank Facility is located approximately 56 m below surface. The water level is so far below the surface that it is highly unlikely the water could flow into any of the streams on Burnaby Mountain.

c) The groundwater beneath Burnaby Mountain flows within bedrock. This bedrock is not currently mapped as, or considered to be, an aquifer. The nearest aquifer is to the southwest (Aquifer #49) and is not used for drinking water supply; it is an unconsolidated sand and gravel aquifer, overlying the bedrock.

During construction of the tunnel or horizontal directional drill beneath Burnaby Mountain, depending on conditions, there may be a need to dewater or pump out groundwater from the tunnel. The operation of the pipeline is not expected to have any effects on the groundwater.

2.3 Acquisition of land on Burnaby Mountain.

Preamble:

It is generally understood that the City of Burnaby owns the land on Burnaby Mountain where Trans Mountain plans to construct a tunnel. It is also known that several First Nations/Aboriginal Nations claim this land as their hereditary unceded territory.

Request:

a) How does Trans Mountain obtain the lands required for the right-of-ways it uses for the installation of pipelines? Will the land required to do the tunneling through Burnaby Mountain be purchased, leased, or expropriated?

Response:

a) In general, Trans Mountain does not purchase or lease lands required for TMEP. In addition, Trans Mountain has no authority to expropriate lands. Should TMEP be approved, the Project would require temporary construction work space, and a permanent easement. The temporary construction workspace is required to provide sufficient space to construct the pipeline. Once construction of the pipeline and restoration of the lands are complete, those lands would revert to the owner. The pipeline easement is a legal instrument that provides a company the right to install, maintain and operate the pipeline. The easement remains registered on title and runs with the land for as long as the pipeline operates.

Trans Mountain has developed a compensation framework, based on legislation and industry practice, for acquiring the easement and temporary construction right-of-way. The Company is actively engaging landowners through the land program and our objective is to reach mutually beneficial voluntary agreements with directly affected landowners. The NEB has a well-defined and rigorous process for ensuring the rights of landowners are protected through this process. Should the NEB grant Trans Mountain approval to construct the TMEP, the NEB Act provides for right-of-entry to construct the pipeline and establishes an arbitration process for resolving differences of opinion between landowners and the company.

2.4 Conservation area on Burnaby Mountain

Preamble:

The Burnaby Mountain Conservation area is an environmentally protected area and home to a variety of wildlife, including resident populations of coyote, bears, bobcats, owls, raccoons, other small mammals, plus migrating and nesting birds. During the preliminary drilling of the bore holes in the Conservation area on Burnaby Mountain trees were removed, soil was displaced, and the Horizons Restaurant was closed to patrons.

Request:

b) Will it be necessary to enter any portion of the Burnaby Mountain Conservation area during the construction of the tunnel?

c) If yes, what type of equipment will be used in the Conservation area?

d) What means will be used to prevent damage to the Conservation area?

e) Will a survey of wildlife numbers be done in advance of construction on Burnaby Mountain?

f) Will traffic to Horizons Restaurant be affected in any way during the construction of the tunnel on Burnaby Mountain?

g) Will access to the Conservation area by residents and tourists be affected in any way during the construction of the tunnel on Burnaby Mountain?

Response:

b) Trans Mountain does not envisage a need to carry out any intrusive construction activities in any part of the Burnaby Mountain Conservation area during the construction of the tunnel.

c) Please refer to the response to b) above.

d) Trans Mountain's primary means of preventing damage to the Burnaby Mountain Conservation Area is through avoidance by the proposed use of tunnel construction methods to install the pipeline. The plan avoids disturbance to the area as the entry and exit points for the tunnel will be located outside the Conservation Area.

e) Since filing of the Application, alternative route options and construction techniques in the area of Burnaby Mountain have been proposed for the Westridge Delivery Lines that extend from Burnaby Terminal to Westridge Marine Terminal (Technical and Project Update No. 4, Part 1 filed with the NEB on December 1, 2014 [Filing ID A4F5D5]). The proposed revised pipeline corridor, which is preferred over the previously proposed pipeline corridor, would use a trenchless construction methodology (*i.e.*, a tunnel) to install the Westridge Delivery Lines. Installing the pipelines through a tunnel would minimize impacts to wildlife and wildlife habitat, as well as the ecological and

recreational value of Burnaby Mountain, by reducing the amount of disturbance and habitat loss. Disturbance caused by trenchless methodologies would be restricted to the proposed entry and exit portals for the tunnel, and would avoid disturbance to the Burnaby Mountain Conservation Area. Wildlife field work would only be completed at the exit and entry portal sites in 2015.

f) At this stage of detailed engineering and design as well as construction planning, the proposed construction of the tunnel under Burnaby Mountain is not anticipated to directly affect traffic to Horizons Restaurant.

g) Until detailed construction planning is complete through 2016, indirect construction impacts will not be completely evaluated. At this time, construction of the tunnel under Burnaby Mountain is not expected to directly affect access to the Conservation area by residents or tourists.

2.5 The Burnaby Terminal (tank farm)

Preamble:

The Burnaby Terminal (tank farm) is located in a heavily populated residential area, close to schools, large housing complexes, parks, and pre-schools.

Request:

a) During the 1964 earthquake, The Valdez, Alaska Tank Farm Fire burned for two weeks. Are there measures in place to prevent such a huge burn, or shorten the duration somewhat? Please describe these measures.

b) How will the new tanks differ from existing tanks at the Burnaby Terminal (tank farm)?

c) What measures are taken to prevent sloshing in the tanks in the event of an earthquake? (Records indicate a strong earthquake was felt in the area in 1946. At that time, a school was shaken from its foundations in the Westridge area.)

d) In the event of a major disaster at or near the Burnaby Terminal (tank farm), it is evident that people must act quickly. It is possible that main travel routes may be closed, and common methods of communication may not be available (radio, TV, cell phone, etc). Given the urgency to act quickly at a time of crisis, how will local residents be apprised of the best evacuation routes? I understand you have an Incident Command System network to rely on for dissemination of information. But this may not be good enough or fast enough for people living close to the Burnaby Terminal. Is there any other resource that local residents can rely on?

e) Canadian residents are, by law, obliged to notify insurance companies of any changes that would increase risk to fire, etc. In the event that insurance rates go up because of the Trans Mountain pipeline expansion and increased tank farm capacity, will Trans Mountain assist residents in covering the increase in home insurance costs where the difference is significant?

Response:

a) A direct comparison with the 1964 Alaska earthquake that affected Valdez is somewhat difficult given the differences in design, commodities, location, geology, and other factors. As discussed in the response to Doherty D IR No. 1.08a (Filing ID A3Y2K2), Trans Mountain intends to design the storage tank foundations, the tanks themselves, the secondary containment systems, and other infrastructure at Burnaby Terminal to withstand large earthquakes with minimal damage or loss of integrity.

According to information on the United States Geological Survey (USGS) web-site, http://earthquake.usgs.gov/earthquakes/events/alaska1964/, the 1964 event in Alaska was a subduction earthquake of magnitude 9.2, with its epicenter 56 miles west of Valdez, and was the second largest earthquake ever recorded worldwide. For comparison, the response to Wembley Estates IR No. 1.8b (Filing ID A3Y3W9) refers to a similar event, specifically "…..it is anticipated that design ground motion will be

equivalent to that resulting from a M7.1 shallow crustal event close to Vancouver and to an M9 subduction event off Vancouver Island".

Aside from appropriate seismic design, Trans Mountain intends to install fire protection systems on or nearby the proposed new tanks, as applicable, that will be designed to address the following fire scenarios at each terminal:

- Tank floating roof rim seal fire (fixed to tank, automated foam application).
- Tank full surface fire (fixed to tank, automated foam application).
- Tank full surface fire (application by portable foam monitors).
- Adjacent tank cooling (application by portable water / foam monitors).
- Release to secondary containment (application by portable foam monitors for odorous & combustible vapour suppression).

Trans Mountain anticipates that the Burnaby Terminal fire protection system will include the following elements:

Fire Water System

- Make-up water connection from the City of Burnaby.
- Expanded fire water reservoir.
- Two fire water pumps (one diesel-powered and one electric-powered).
- Fire water distribution system.
- Hydrants located throughout the expanded areas of the terminal.
- Portable water monitors.

Fire Foam System

- Foam storage tank and injection system.
- Foam distribution system.
- Fire detection equipment on the new storage tanks.
- Foam distribution and application systems on the new storage tanks.
- Foam manifolds located throughout the expanded areas of the terminal.
- Portable foam monitors.

Trans Mountain has seismic monitoring instruments at Burnaby Terminal today and will add additional seismic monitors as part of the Project. There will also be a standby generator to ensure that power supply is available to critical control systems and valve actuators in case of utility power failure.

b) The proposed new storage tanks at Burnaby Terminal will be similar to the existing storage tanks, although there will be a few differences as listed below.

- 13 of the 14 new tanks will be larger than the existing tanks. The diameters currently selected for these tanks range from 53.3 m (175 ft.) to 61.0 m (200 ft.). Nine of the 13 existing tanks are 45.7 m (150 ft.) in diameter and four are 36.6 m (120 ft.) in diameter.

- All of the new tanks will be taller with shells that are 18.3 m (60 ft.) tall. The majority of the existing tanks have 14.6 m (48 ft.) tall shells.
- All of the new tanks will have fixed roofs as well as floating roofs. Six of the 13 existing tanks have fixed roofs and the remainder only have floating roofs. Some of the existing tanks that have fixed roofs have light-weight floating roofs. The new tanks will all have steel pontoon floating roofs.
- All of the new tanks will have Tank Vapour Adsorption Units (TVAUs) for odour control. Three of the existing tanks have these types of systems.
- All of the new tanks will have automated rim-seal and full-surface fire-protection permanently connected to a foam supply system. The existing tanks have rim-seal fire protection. Some upgrades to the existing tank fire protection systems are currently underway.

c) The consideration of sloshing effects in American Petroleum Institute (API) Standard 650, Welded Tanks for Oil Storage, Annex E is for the purposes of the structural design of the tank and establishing appropriate freeboard (the distance that the maximum liquid level is below the shell). The convective (sloshing) period is calculated and used to determine other parameters, such as the convective spectral acceleration parameter. These parameters are, in turn, used to determine forces, such as the dynamic hoop tensile stress, which are then used to determine the structural design of the tank. API 650, Annex E does not identify any measures to prevent sloshing in a tank; it is assumed to occur during an earthquake and the intent of the design is to resist the effects of it.

d) Kinder Morgan Canada (KMC) uses the Incident Command System to respond to emergencies. Under the Incident Command System, the Information Officer is responsible for public notifications in the event of an incident. Public notification priorities are determined based on the type of incident and the impacts it has to the safety of the public. KMC works with local authorities in the event of an emergency to coordinate response, including immediate notifications as required.

Specific communication strategies will depend upon the nature of the incident and would be approved under the Incident Command System. KMC is committed to timely communications with those that are directly impacted by any emergency event. The methods used for informing the public include door to door delivery of information, social media, traditional media, website updates and a phone hotline. KMC maintains a standby website that can to be activated and populated as needed, the hotline is also ready to go live at the time of an incident. The public is notified about the hotline number via the website, social media and traditional media, along with an information package that may be prepared for distribution to those impacted by an emergency, and/or at open house style events.

KMC takes full responsibility for any emergency that results from the Trans Mountain Pipeline system and its facilities and plans to jointly manage such an incident with the

local, provincial and federal authorities in the jurisdiction of the emergency using Unified Command. The current planning method calls for the replacement of municipal services with private firms as early in a response as possible, with the approval of Unified Command.

e) Given Trans Mountain is proposing to continue using the Burnaby Terminal as a pipeline terminal and the expansion will remain within the existing boundaries of the Burnaby Terminal, Trans Mountain does not anticipate that its activities will cause increases in property insurance for homes in the community. However, if a home owner does experience an increase in insurance rates directly attributable to Trans Mountain Expansion Project, we would expect the homeowner to provide supporting information to the Manager, Land for Trans Mountain. The Company will investigate these costs and will provide any commensurate compensation due to the homeowner where justified.

2.6 Questions arising from responses to IR No 1.

Reference:

Trans Mountain response to D. Doherty, page 15 of 42:

> n) Proposed Tank 79, the most southerly of the eastern group of tanks at Burnaby Terminal will be located approximately 75 m (250 ft.) from the southern property line. Note that the southern property line is somewhat north of the edge of the Forest Grove community as defined by the City of Burnaby. This distance exceeds the set-back for petroleum storage adjacent to residential areas, identified in the City of Burnaby bylaws as 61 m (200 ft.). Proposed Tank 78, the most easterly of the eastern group of tanks will be approximately 40 m (130 ft.) from the eastern property boundary. There is no set-back identified for petroleum storage adjacent to parkland in the City of Burnaby bylaws.

Request:

a) The tanks discussed in n) above are cited as being approximately 75 m and 40 m from the property line. Please indicate which part of the tank is referred to, the outer wall of the tank, or the surrounding moat?

b) Will you be consulting with neighboring property owners before you excavate for the installation of the tanks to ensure property boundaries are correct?

Response:

a) The part of the proposed storage tank that is referred to in the response to Doherty D IR No. 1.03n (Filing ID A3Y2K2) is the shell (i.e. outer wall) of the tank not the edge of the secondary containment area (surrounding moat).

b) Prior to commencing construction of any facilities, Trans Mountain would conduct legal surveys to ensure the facilities are constructed in the design locations and are fully contained within Trans Mountain property.